Stratified Coastal Trapped Waves and Mean Flows

PI:
LuAnne Thompson
School of Oceanography
Box 357940
University of Washington
Seattle, WA 98195
phone: 206-543-9965 fax: 206-685-3354 email: luanne@ocean.washington.edu

Co-I:
Daniel R. Ohlsen
Program in Atmospheric and Oceanic Sciences
Campus Box 311
University of Colorado
Boulder, CO 80309-0311
phone: 303-492-8237 fax: 303-492-3524 email: Daniel.Ohlsen@colorado.edu

Award # N00014-96-1-0066

LONG-TERM GOALS

Our long term goals are to identify the roles that rectified subinertial waves and mesoscale motions play in the mean-flow transport of fluid properties in the coastal ocean and to apply these ideas to cross-margin transport of physical, chemical, and biological properties.

OBJECTIVES

Coastal waves and wave-generated mean flows are studied in a stratified, rotating model ocean. Waves trapped to the coast are generated by time-dependent flow over a sloping and irregular bottom. Short-term goals of this study include quantifying the evolution of the vertical structure of the along-slope mean flow driven by non-linear interactions of the coastal trapped wave and damped by friction. In particular, the effects of stratification on the cross-slope overturning circulation will be examined.

APPROACH

The approach for this research is to use laboratory experiments and two types of numerical models. The laboratory experiments are fully non-linear by their very nature, while the numerical models provide a useful venue for studying specific processes and offer much better diagnostics.

In the lab experiments, a bowl-shaped tank with radial ridges provides the coastal slope and cross-slope topography to generate wave motions. The entire apparatus rotates and

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Stratified Coastal Trapped Waves and Mean Flows**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,School of Oceanography,Seattle,WA,98195**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

flow over the topography is achieved with a slight spin-up or -down of the rotation rate. The water in the bowl is stratified with salt to give a vertical density gradient. Waves are generated by the topography and trapped to the coast by the planetary rotation. The fluid motions are observed by tracking the paths of neutrally-buoyant particles at multiple vertical levels. The initial and evolving stratification is measured with a micro-CTD probe.

Two numerical models are used. One is the coastally trapped wave model developed by Ken Brink and Dave Chapman at WHOI for the study of the linear response, and a fully non-linear isopycnal numerical model is being used to directly simulate the laboratory experiment with laboratory geometry and parameters.

WORK COMPLETED

The laboratory experimental results are discussed in the annual report by Ohlsen. The following numerical modeling work has been completed

1. The numerical model has been configured for the laboratory experimental configuration (described in the Ohlsen Annual Report). Qualitative comparisons to the laboratory experiments have been done.

2. The Brink/Chapman linear coastal trapped wave model has been used to find resonant points for the laboratory configuration. The first mode has a bottom trapped structure and the frequency of this mode is quite low, suggesting that the laboratory experiments have been run fairly far from resonance thus far.

3. A new formulation for the residual circulation (the cross-slope circulation of mass in the quasi-linear problem of wave-mean flow interaction) has been developed and will be applied to output from the Brink and Chapman model in the next year.

RESULTS

Comparisons between the laboratory experiments and laboratory model (Figures 1 and 2, compared to Ohlsen annual report Figures 1 and 2) suggest that the qualitative evolution of the mean flow (average azimuthal velocity) is independent of the form of the frictional parameterization, but the time-scale over which the azimuthal velocity slows does depend strongly on friction, although the structure does not (Figure 2). This suggests that wave-mean flow interaction for coastally trapped waves is relatively independent of the frictional parameterization in its structure, although the magnitude of the effects on the mean-flow do depend on friction.

With finite amplitude topography, mean flow modification occurs near the topography in each layer. From preliminary analysis, the mass flux is upslope narrowly confined to the boundary when waves are present, with a broader return flow, and has a more uniform structure when waves are not present. Comparisons to the structure of the linear wave modes (Figure 3) show that the mean-flow modification and mass-flux have a different structure.

The new formulation for the residual circulation will allow consideration of the mass flux that would come from either wind-forced coastally trapped waves such as those observed off the California Coast, or that associated with the interaction of along-shore flow over topography. The new formulation is necessary because of the presence of finite topography, a situation that can not be dealt with in quasi-geostrophic theory and is a situation that is not of interest to atmospheric scientists so has not been considered.

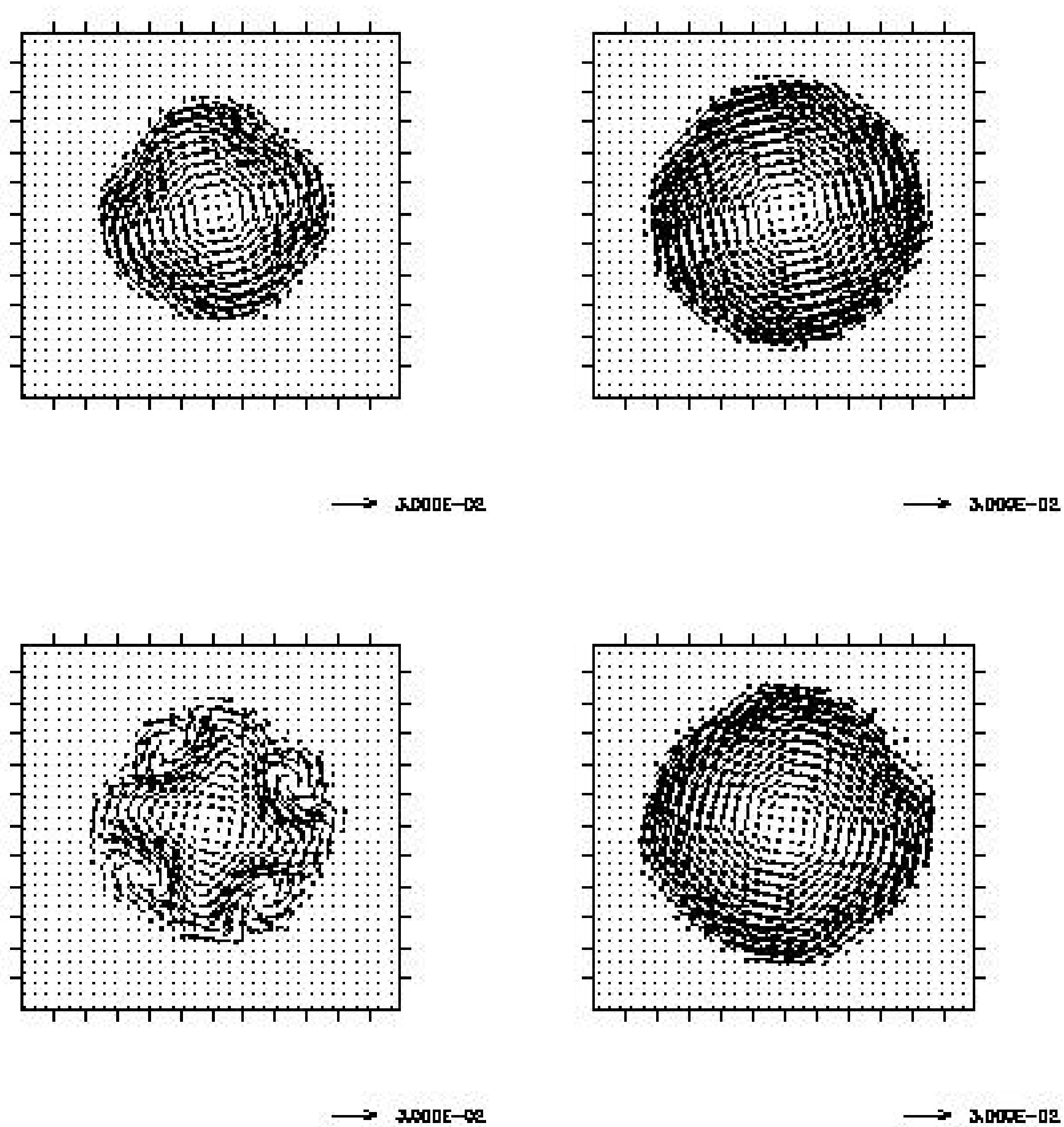

Figure 1. Numerical model velocity for second layer (right panels) and third layer (left panels) for cyclonic (upper panels) and anticyclonic (lower panels).

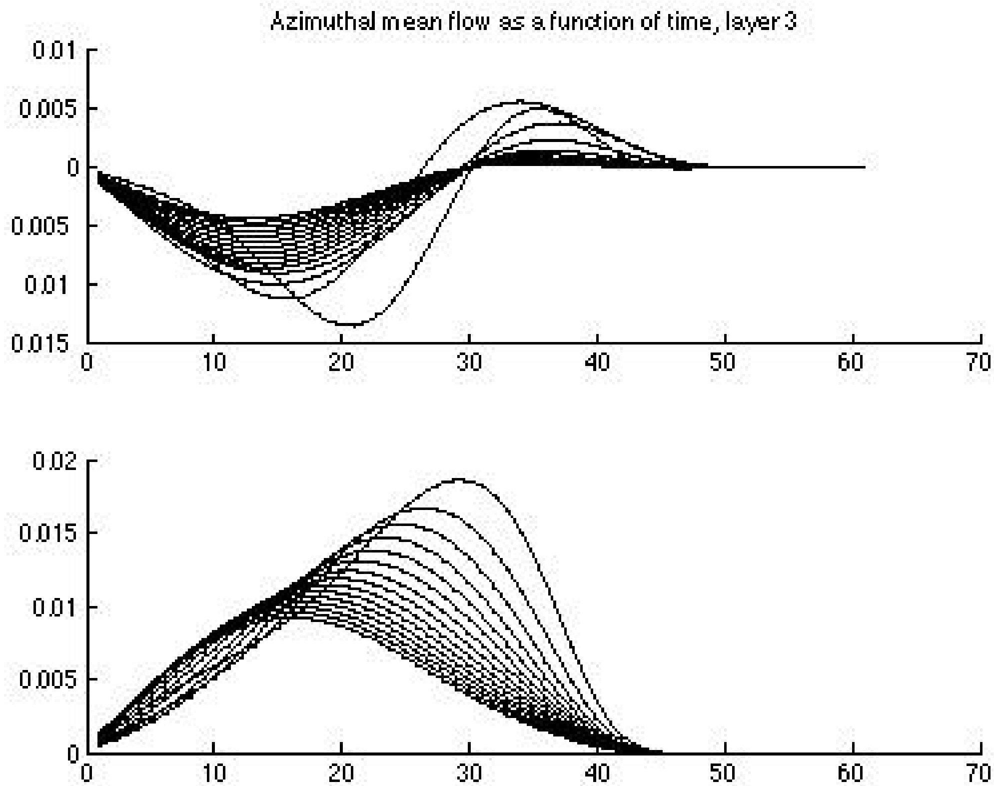

Figure 2. Azimuthal mean flow for anticylonic (upper panel) and cycloni(lower panel) every 4 s over time. The comparison of these figures with the laboratory experiments are good.

Figure 3. The first mode wave structure for CTW using the laboratory configuration of Ohlsen.

IMPACTS/APPLICATIONS

We expect to gain a new understanding of one possible forcing mechanism of cross-margin transport and extend our results to wind-forced wave motions on the continental shelf. The difference between the spin-up and spin-down cases suggest that there will be large differences in the cross-slope transport for northward or southward mean flows on the coast. The qualitative similarity of the motions in the laboratory and numerical models suggests that friction parameterization is not critical to applications of these ideas to the coastal ocean.

TRANSITIONS

RELATED PROJECTS

REFERENCES

Ohlsen, D.R. and L. Thompson, 1997: Laboratory study of stratified coastal waves and mean flow, AMS Atmosphere and Ocean Waves and Stability Conference abstract, Tacoma, WA, June, 1997.

Thompson, L., D. Darr, and D.R. Ohlsen, 1997: Stratified coastal trapped waves and mean flows, AMS Atmosphere and Ocean Waves and Stability Conference abstract, Tacoma, WA, June, 1997.